U-Pb Zircon Age Constraints on the Tectonic Evolution of the Northern Margin of the North China Craton and Southern Margin of the Central Asian Orogenic Belt

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Abstract

The Precambrian North China Craton (NCC) is the old continental core of China with published ages ranging from 1 to 2.6 billion. Along its northern edge it is in contact with the collided ~400-500 Ma Bainaimiao volcanic arc and other crustal fragments in the Central Asian Orogenic Belt (CAOB). Along this margin, the NCC is overlain by a passive margin sequence dominated by quartzites. I obtained U/Pb detrital zircon analyses on four samples from these quartzites and on two samples from sandstones in a molasses-filled basin farther south in the NCC. We also dated zircons from plutons intruding the NCC, overlying quartzites, and Bainaimiao arc. The analyses of zircons were conducted at the Arizona using the Laser-Ablation Inductively Coupled Plasma Mass Spectrometer, which enables a quick age determination of multiple zircons in samples providing clues about maximum depositional age and provenance of sedimentary units and emplacement ages of plutons. The four quartzites display minimum zircon ages of 1.2 b.y. and maxima at 1.6 to 2.5 billion. The southern sandstones have minimum zircon ages of ~270 Ma and older maxima at 400 Ma and 1.9-2.0 to 2.4 billion years. Two plutons had 400 to 500 Ma ages and all others had ages of ~262 Ma. These data suggest that the NCC craton remained a passive margin until ~500 Ma, during which it largely received sediments from the NCC. Subduction, magmatism and volcanic arc formation occurred between 500-400 Ma, southern basin formation between ~270-260 Ma and final collision between the NCC and CAOB and intrusion of post collision granites by ~260 Ma.

Geologic Background

Archean Basement

The Early Proterozoic to Archean basement is variable in rock types but contains mostly orthogneisses. The metamorphic assemblagesand magmatic epidote suggest deposition of greater than 20 km, which have now been exposed.

Collided Paleozoic Arc

The collided Paleozoic oceanic arc contains an assemblage of basalt to rhyolite, with lots of clastic tuff units and volcaniclastic sediments. There are also some traces of deep-water sediments. There are some questions about the age, with indications that it may be as old as Silurian. Its composition is pretty heterogeneous, but very deformed so difficult to be certain.

Granite Xenolith in Basalt

Clastic Metavolcanics

Passive Margin

The Middle Proterozoic passive margin is composed mostly of quartzite, marble and phyllite. The quartzite displays ripples, crossbeds, flute casts, trace fossils, and graded beds, which indicates deeper water deposits to the south. There is also a sharp boundary between the passive margin and the basement below it.

Ripples

Flute Casts

Cross Beds

Graded Beds

Mafic Enclave

Garnet-Rich Pluton

Permo-Triassic Granites

The Permo-Triassic, high-potassium, two-mica granite plutons contain magmatic muscovite and garnet localities.

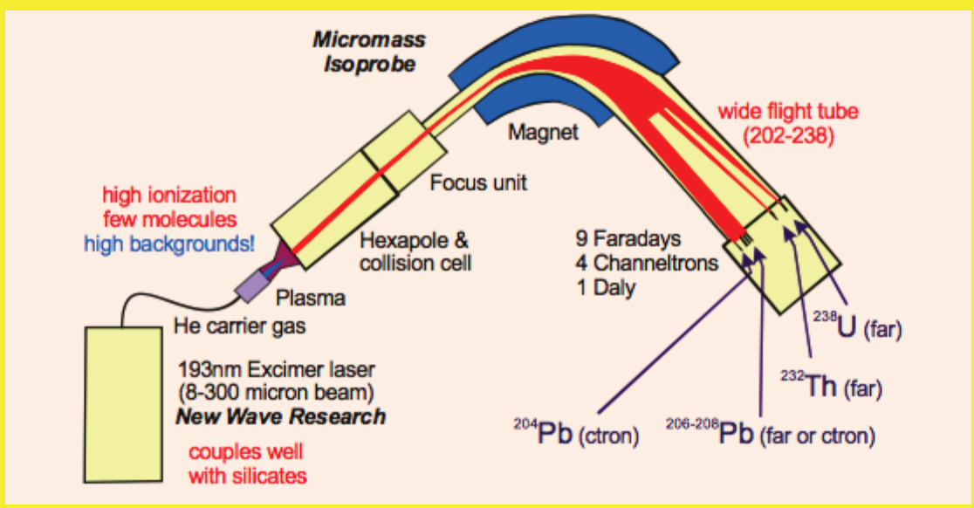
Molasse Basin

The most recent geologic feature is the Mesozoic basins that include Permo-Triassic molasse, Late Jurassic terrestrial sediments, and Late Cretaceous terrestrial sediments (sands and lake deposits).

Volcanic Dominated

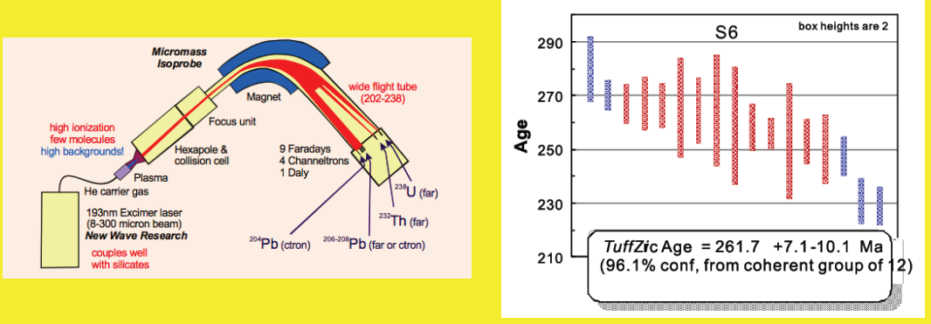
Polymictic Conglomerate

Geochron Analysis

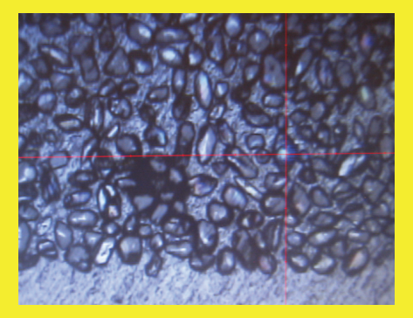


Instrument used for U-Th-Pb analyses, shows strengths (in red) and challenges (in light blue).

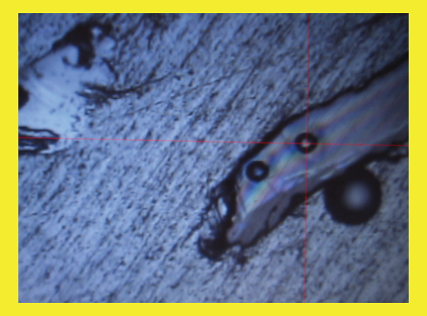
Close-up of Zircons



Zircon Sample Mount

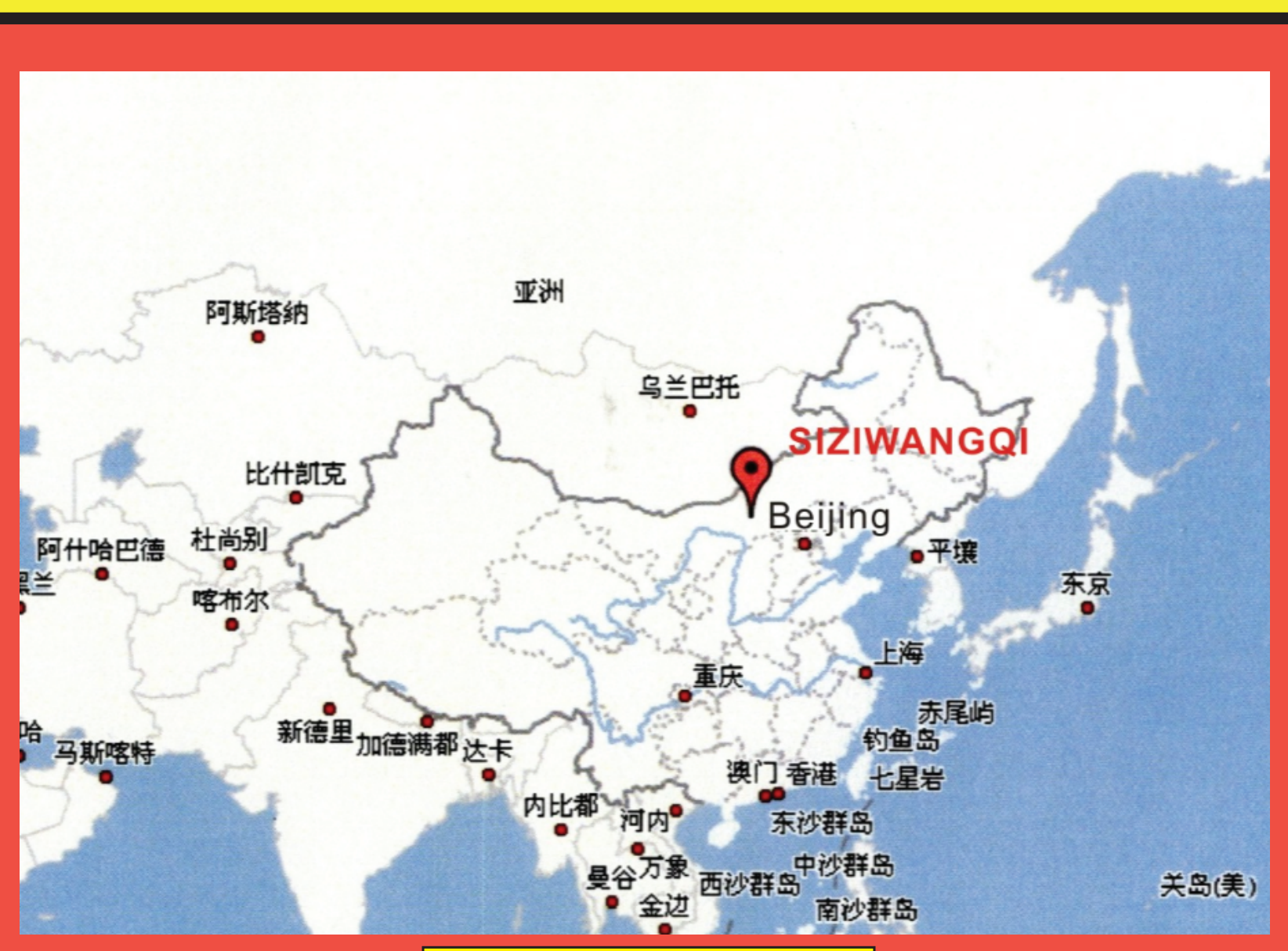


Zircon Selection for the Laser

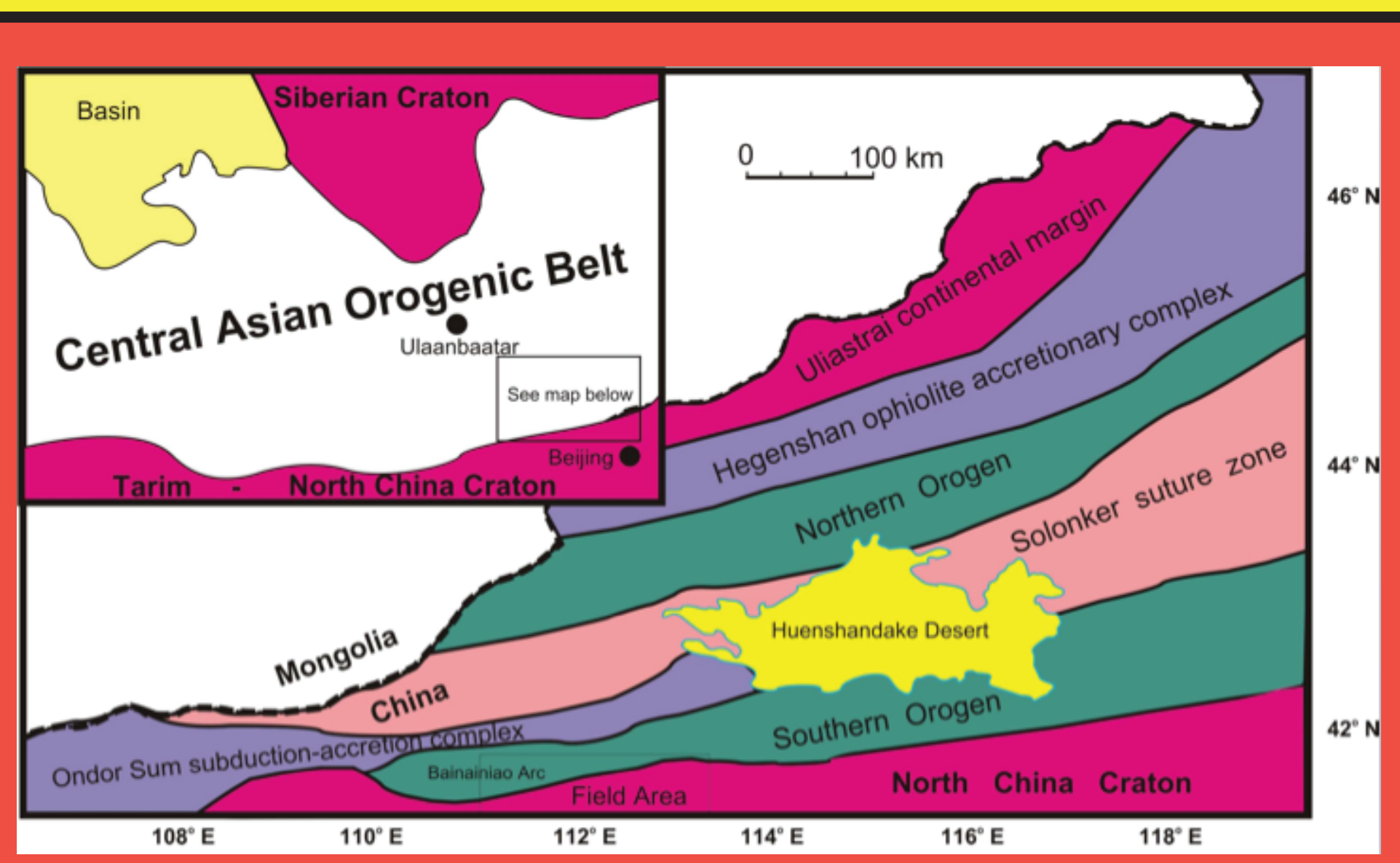


U-Th-Pb geochronology has become a fundamental tool in Earth Science research, with applications that cover the span of structural geology. Analyses are conducted in static mode, with U and Th in tectonics, stratigraphy, paleontology, petrology, and geochemistry. Laser-ablation multicollector ICP mass spectrometers, which allow for rapid determination of U-Th-Pb ages with micron-scale spatial resolution.

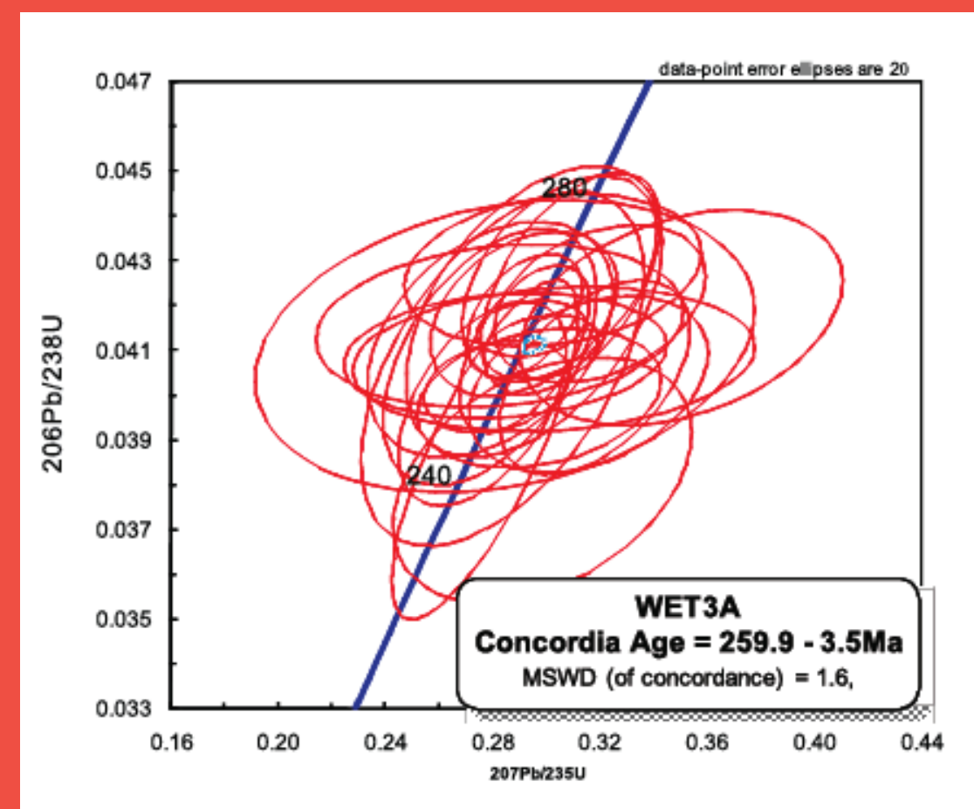
Analyses are conducted in static mode, with ^{238}U and ^{232}Th in faraday collectors, ^{204}Pb in a channeltron, and $^{206-208}$Pb in either faraday collectors (with 10^{12} ohm resistor for ^{207}Pb) or channeltrons. Each analysis takes ~60 seconds, with 12 seconds on backgrounds (on peaks with no laser firing), 12 seconds on peaks with laser firing, and 30 seconds of purge between samples. Beam size is selected according to the size and complexity of crystals, with typical beam sizes of 10-35 microns.



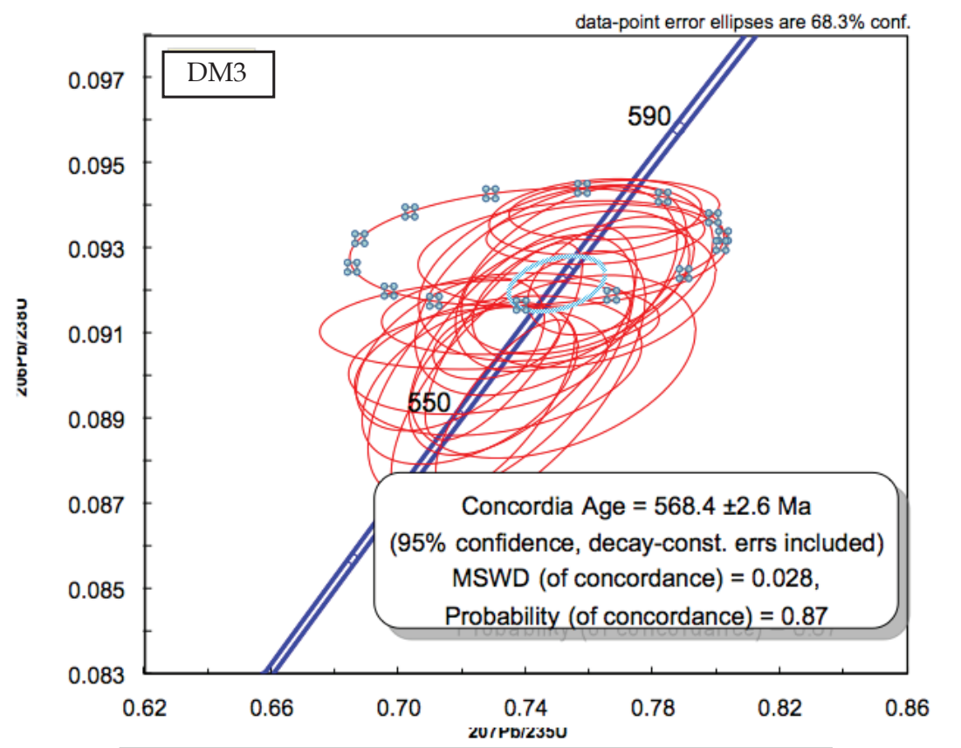
Study area in China



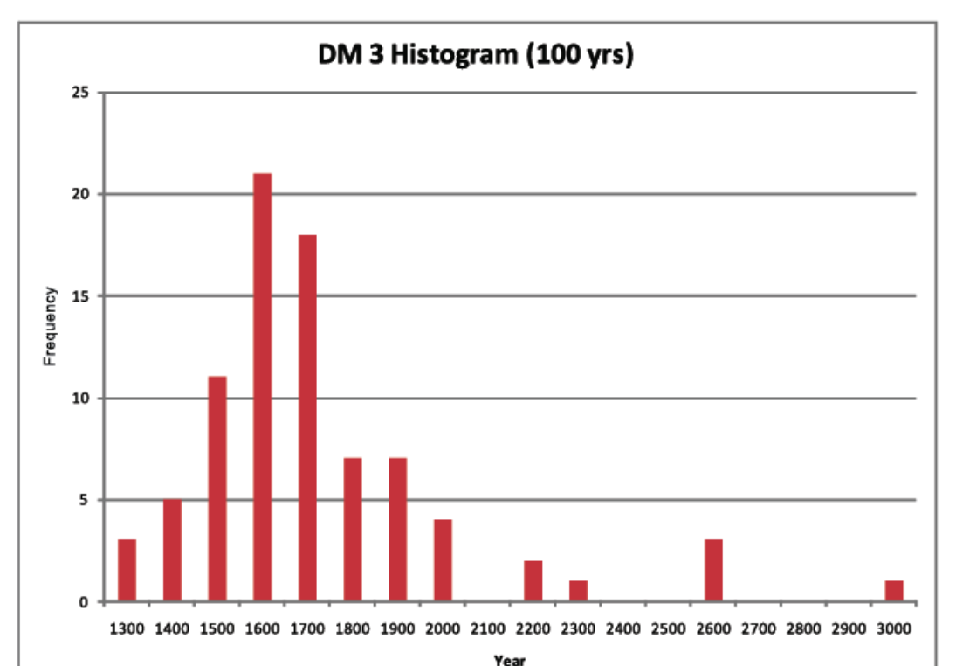
Tectonic units in study area



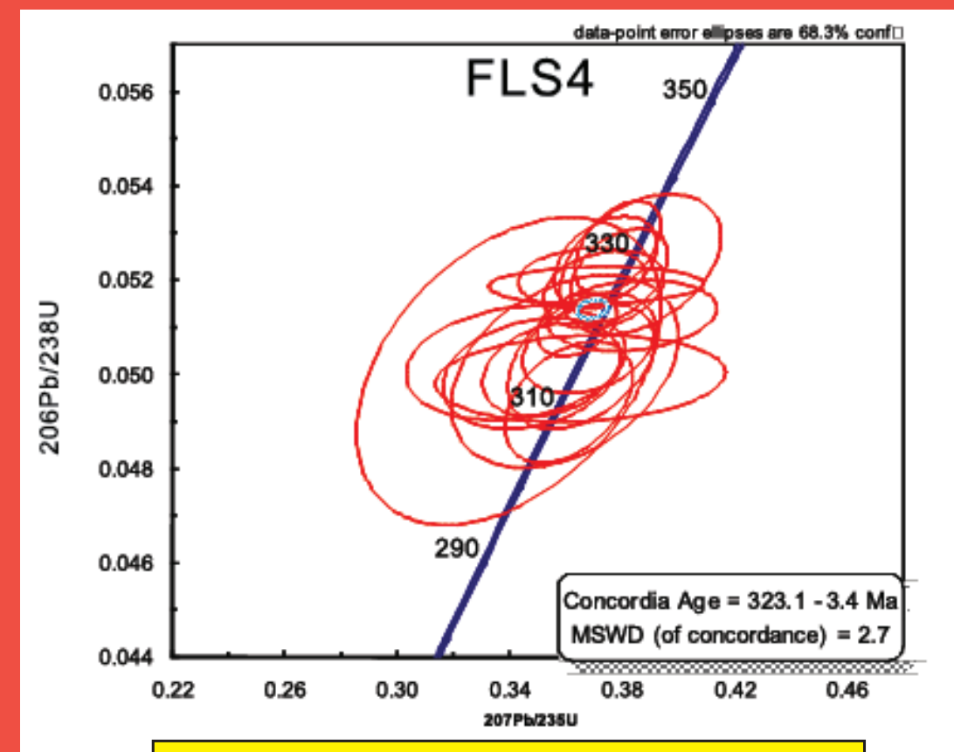
Concordia plot of zircon ages



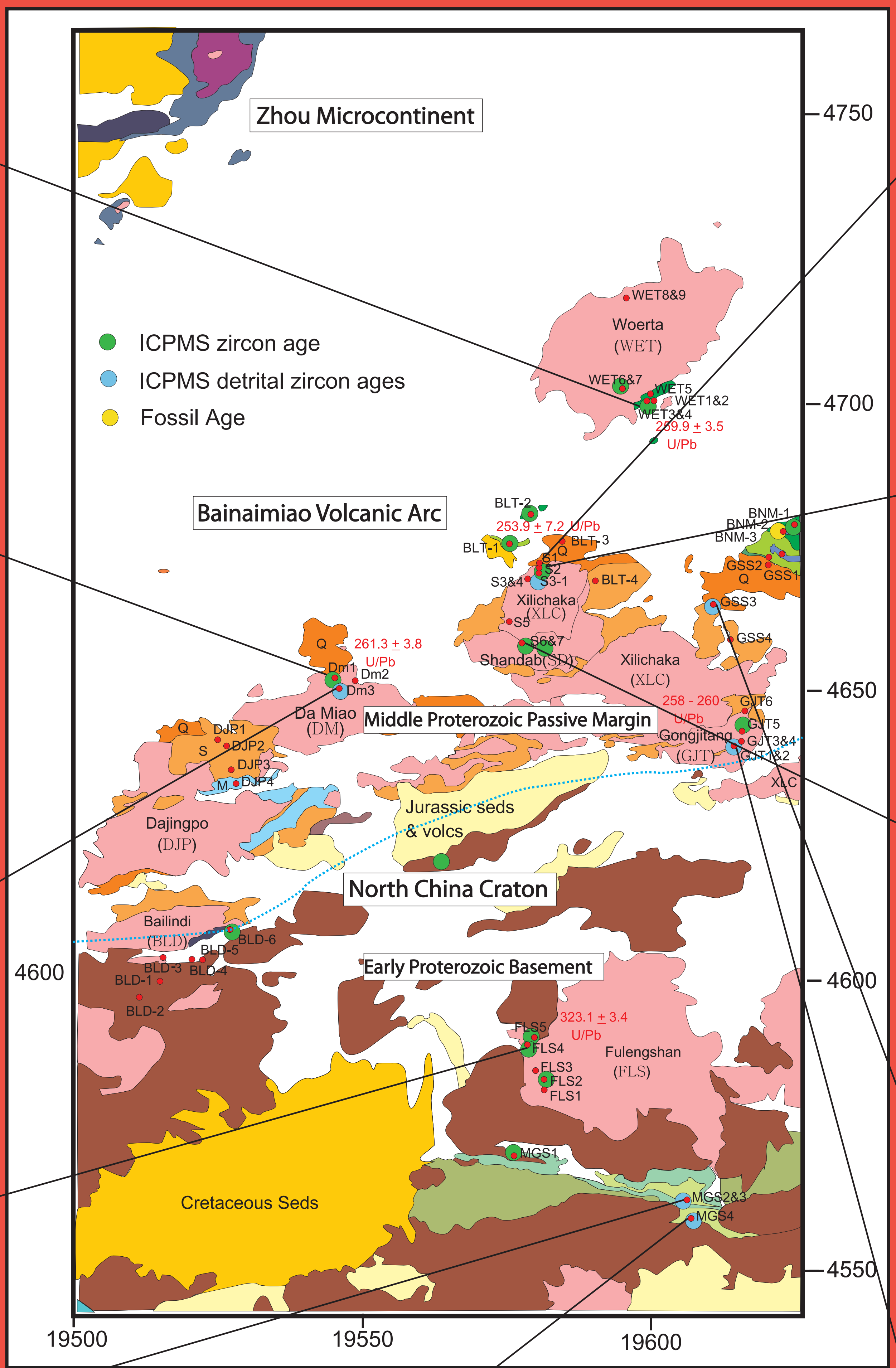
Concordia plot of zircon ages

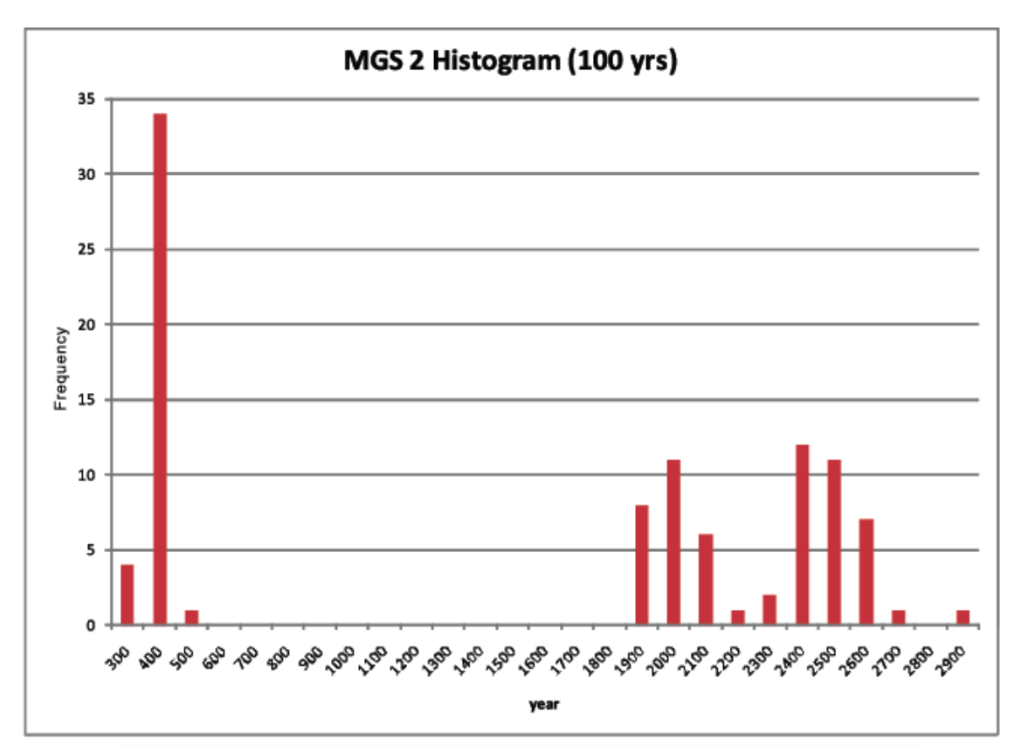


Histogram of detrital zircon ages

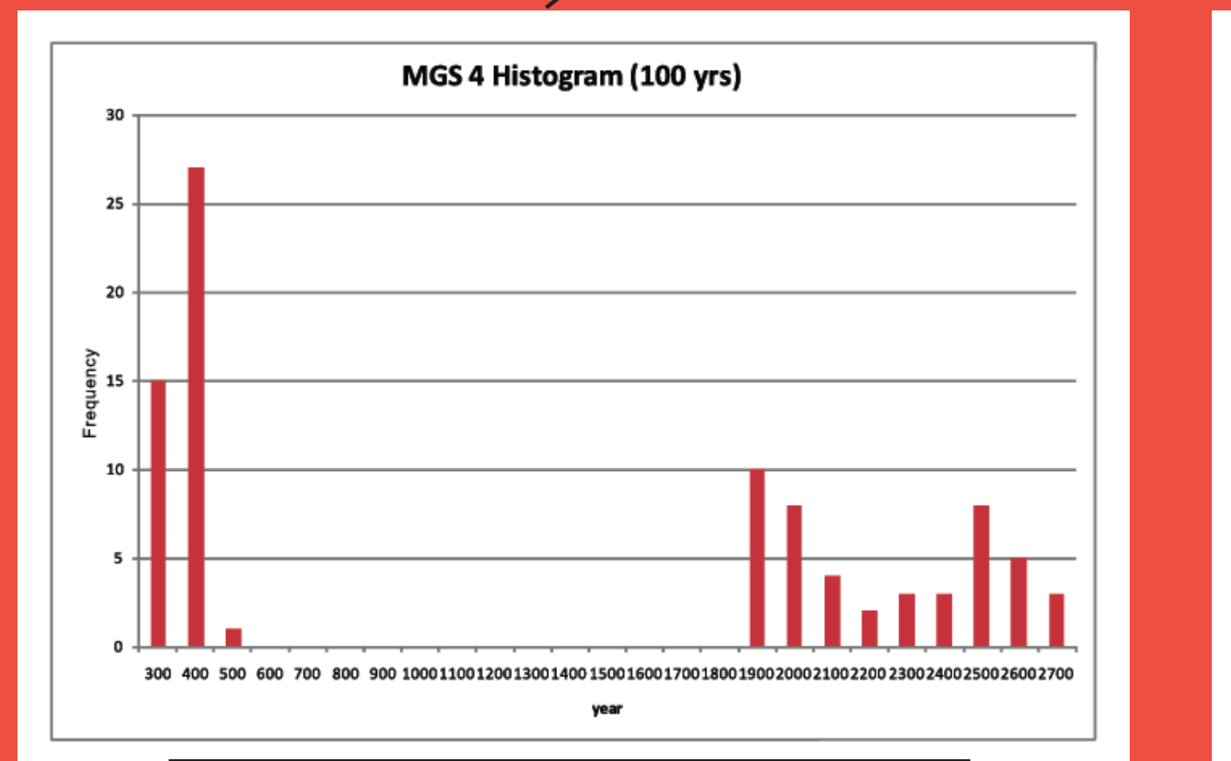


Concordia plot of zircon ages

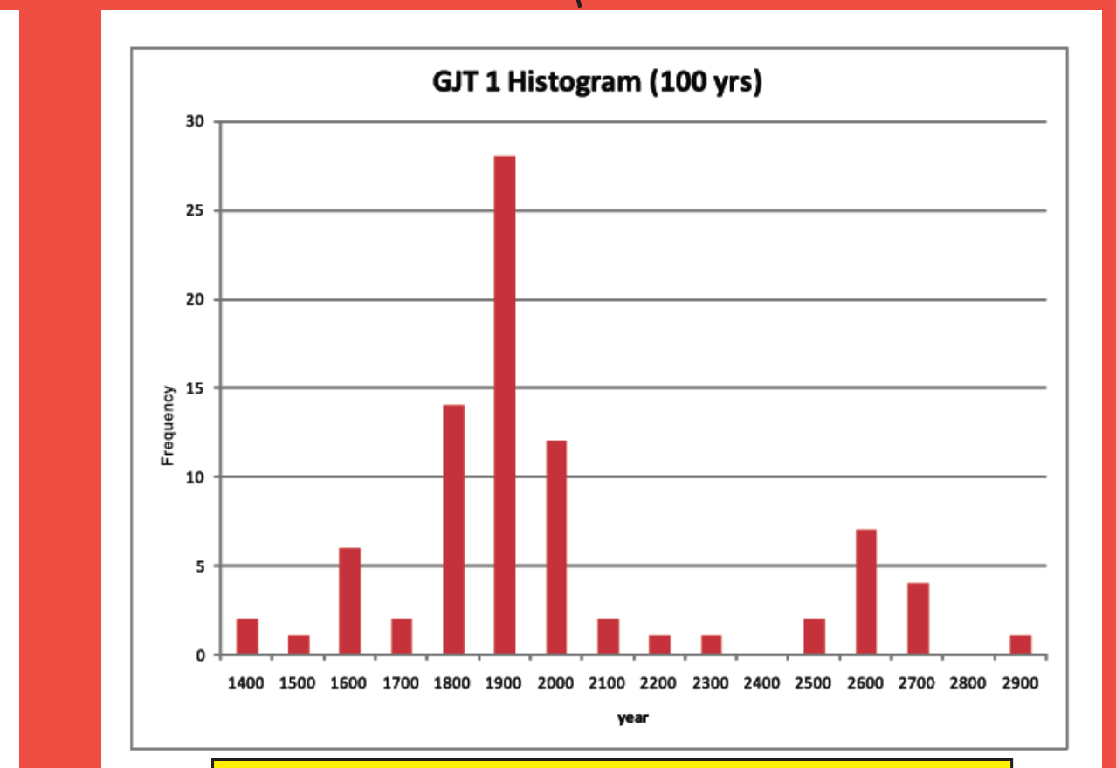




Histogram of detrital zircon ages



Histogram of detrital zircon ages



Histogram of detrital zircon ages

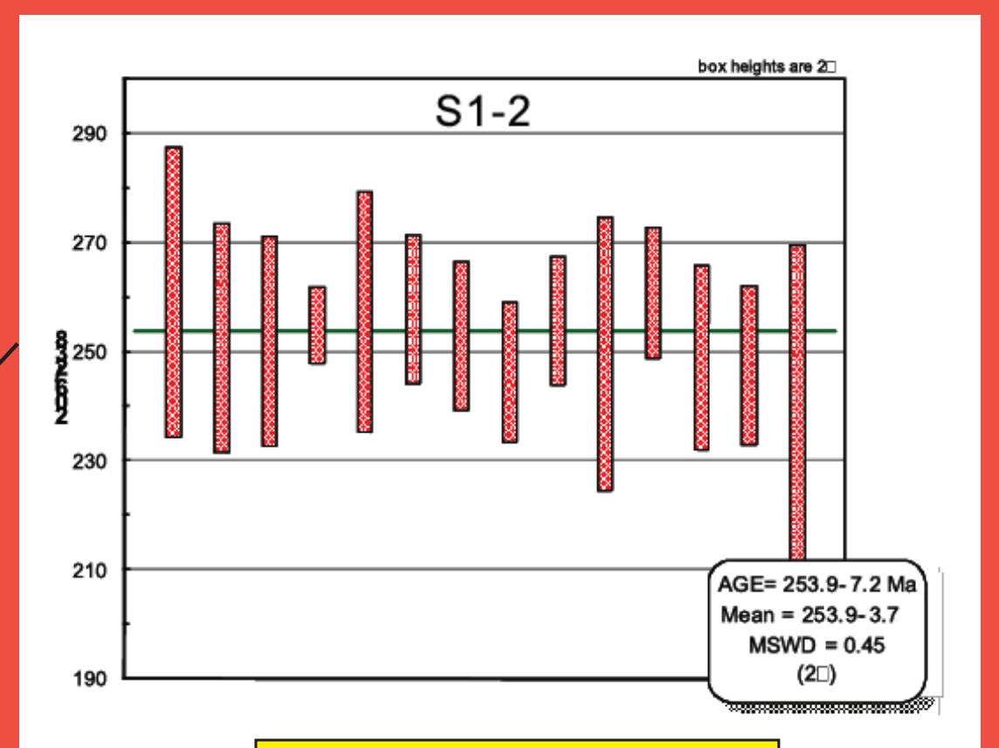
Shallow Water Fossils in Permian Limestone

Crinoid

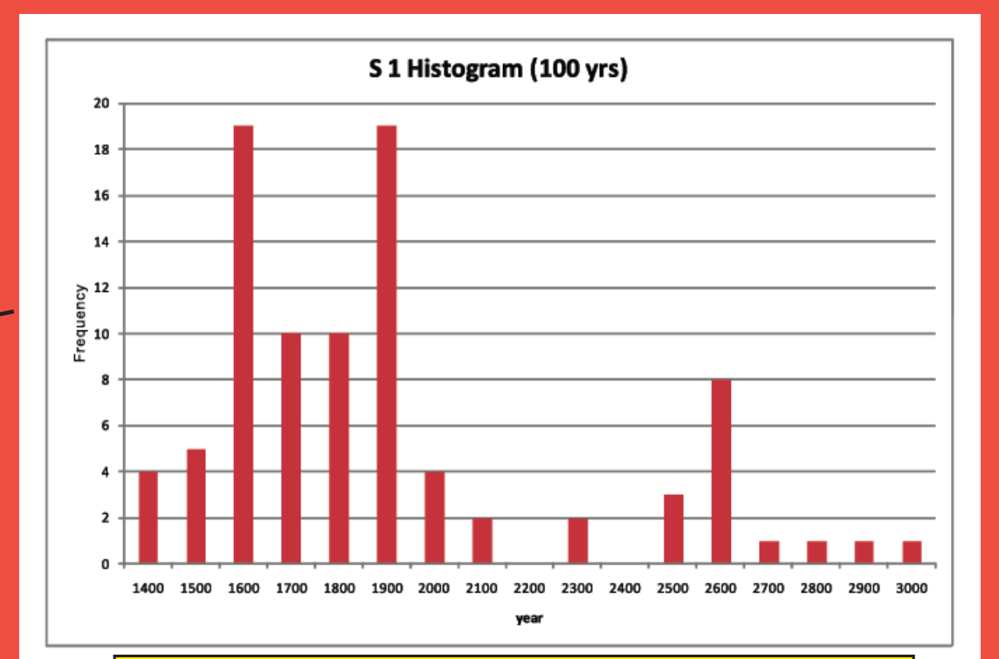
Coral

Foram ?

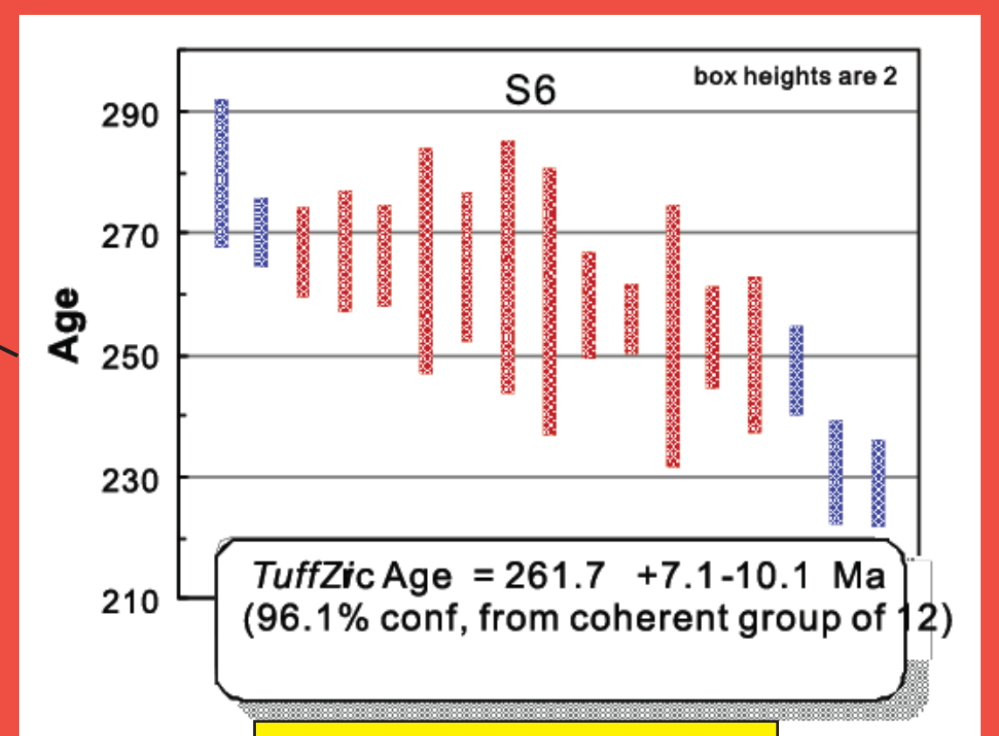
Forams



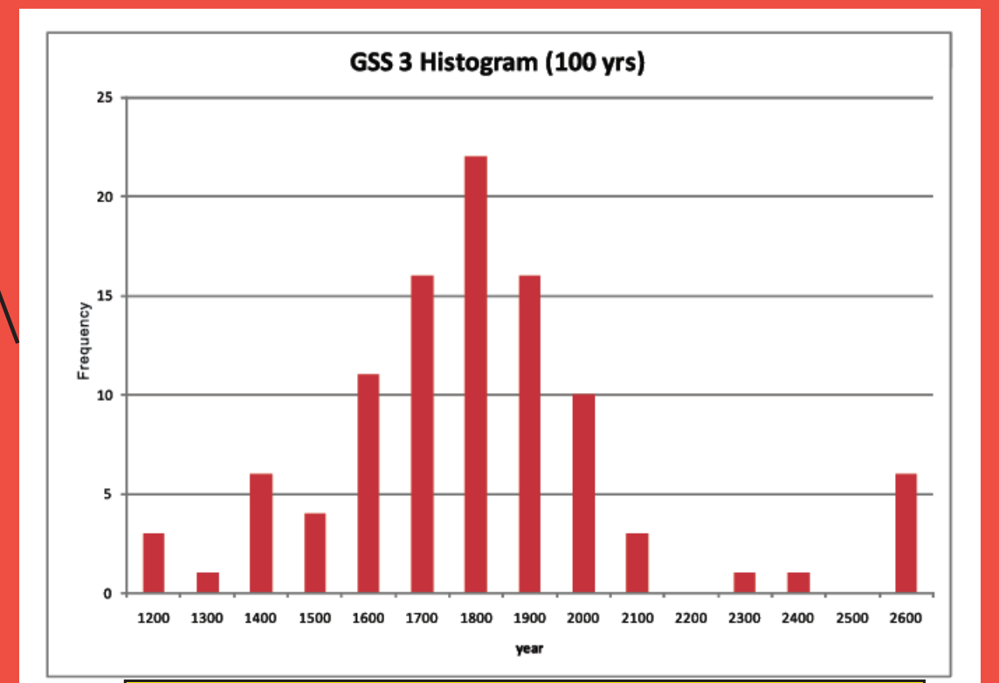
Zircon ages of pluton



Histogram of detrital zircon ages

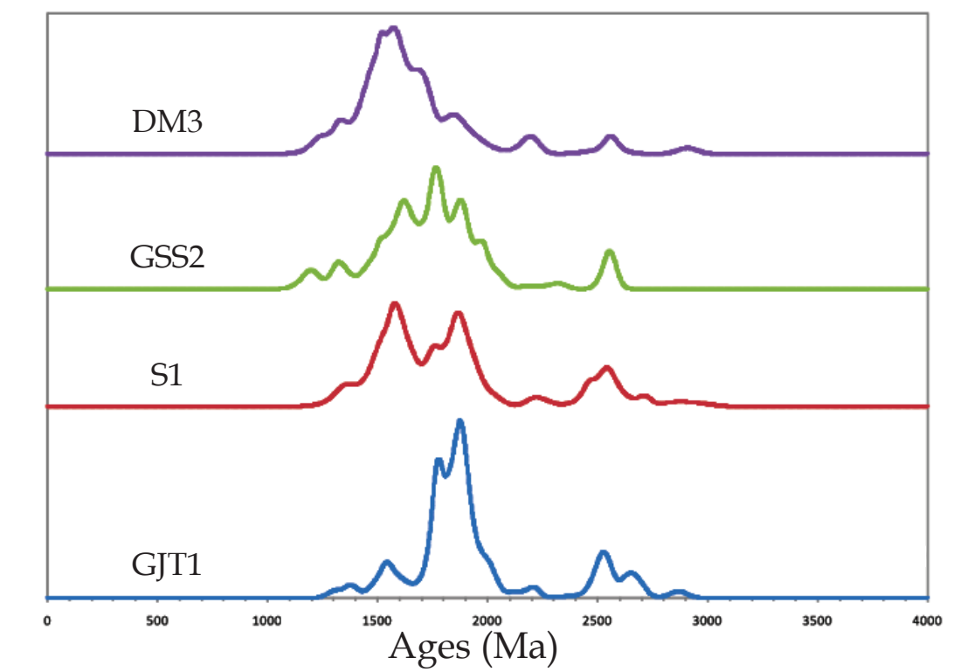


Zircon ages of pluton

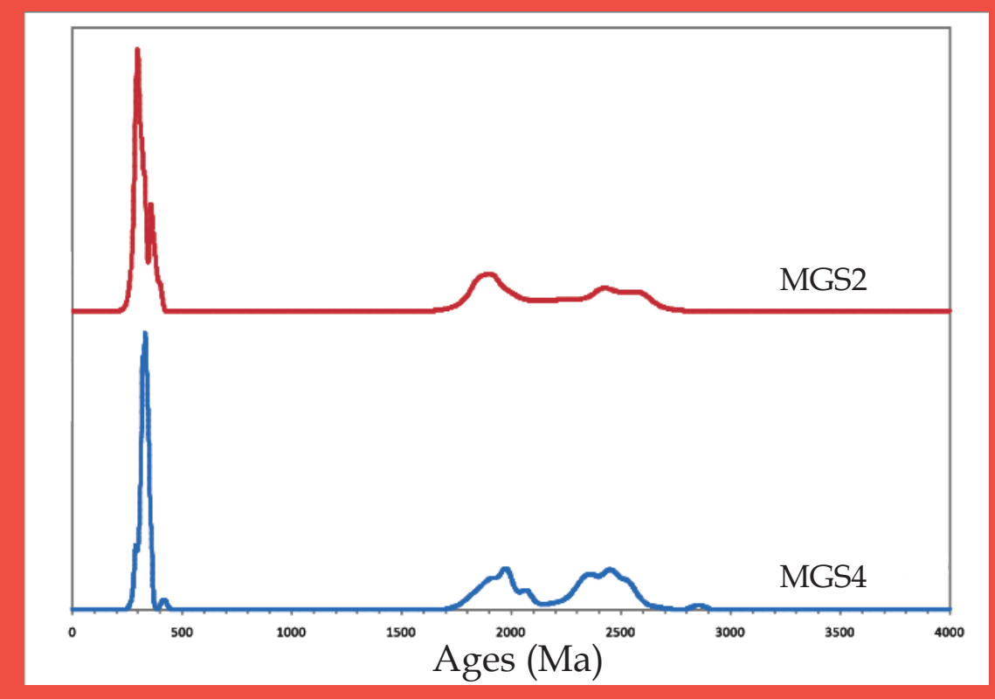


Histogram of detrital zircon ages

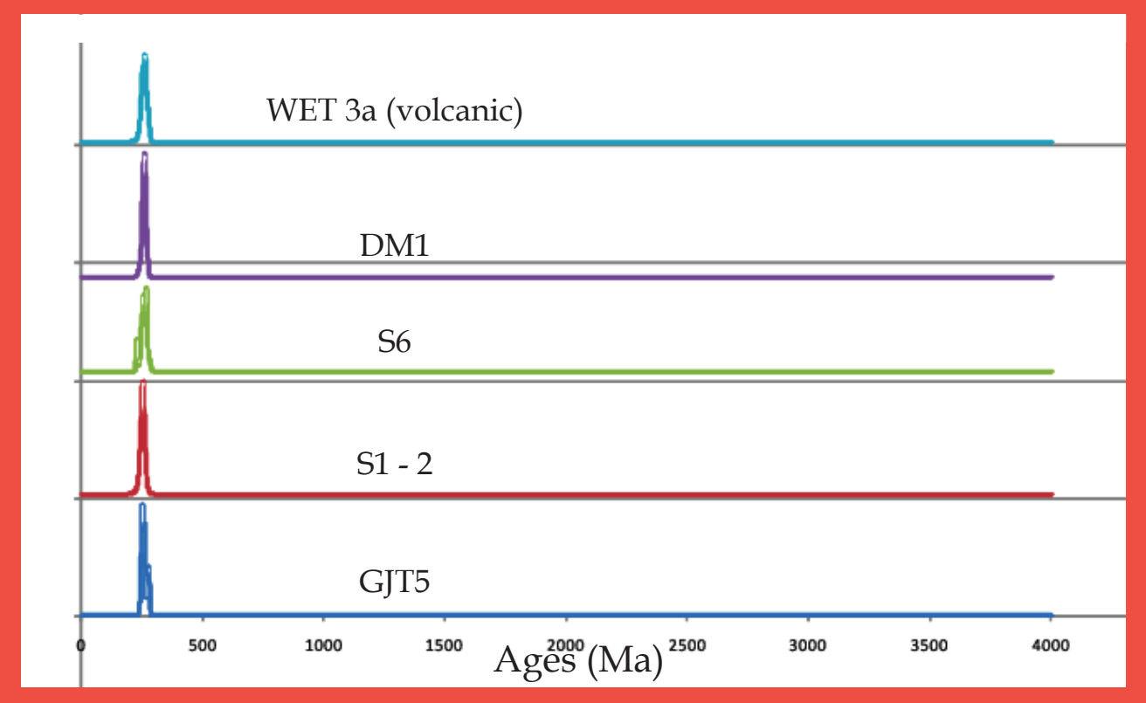
Comparison Graphs of Geochronology



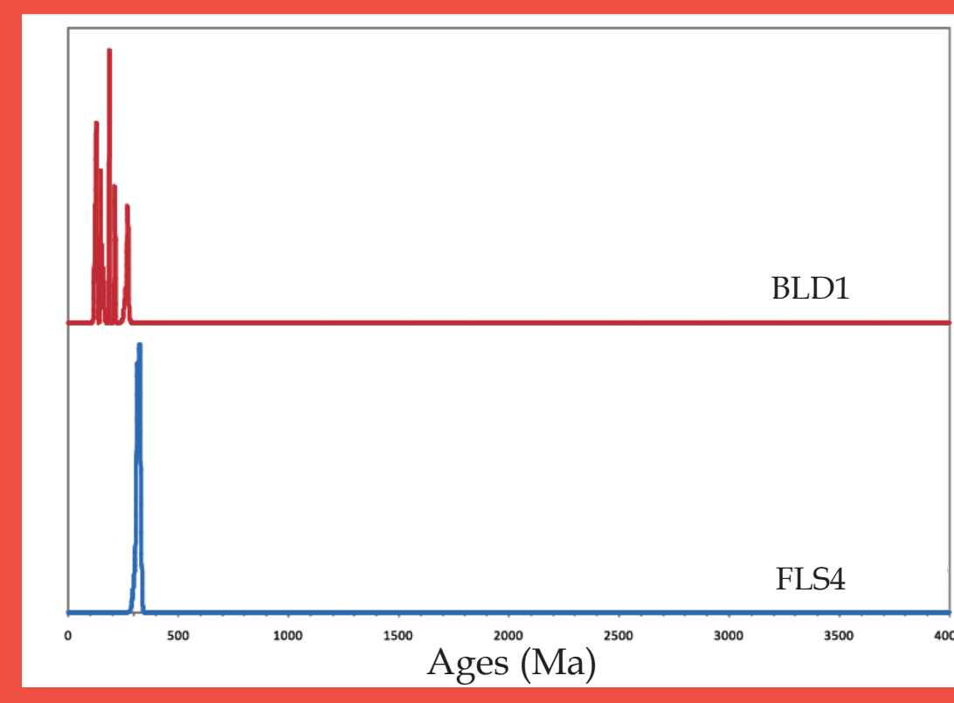
Passive Margin Quartzites



Southern Basin Molasse



Mesozoic Arc Plutons



Paleozoic Arc Plutons

Tectonic Model

Late Archean – Early Proterozoic: Basement shield formation

The North China Craton is an old early Proterozoic (with some evidence of Archean) basement shield that was formed at depths of about 20 km, and then brought to the surface.

Middle Proterozoic: Passive Margin

A passive margin is the transition between oceanic and continental crust that is not an active plate margin. It is constructed by sedimentation above an ancient rift. It forms by erosion of NCC basement rocks and redeposition to form quartzites.

Middle Proterozoic – Paleozoic: Quartzites

The Quartzites display a range in ages with two main peaks at approx 2.5 billion and 1.2-2.0 billion years. The older peak in the quartzite corresponds to the approximate age of the shield. The second peak represents the oldest age possible of the quartzite which would be 1.2 billion years.

Paleozoic (Permo-Triassic): Magmatism

Two older plutons with ages of 4-5 hundred million years intrude basement and passive margin quartzites. These plutons set a minimum age of five hundred million years for the quartzite, due to the plutons intruding these quartzites.

Mesozoic: Molasse Basin

A Southern basin in the shield contains younger sandstones. These sandstones display relative ages similar to that of the quartzite with peaks at approx 2.5 billion and 1.2-2.0 billion. But they also have a big peak at 3-4 hundred million years that is representative of the sediments of the above plutons.

Mesozoic: Magmatism

Plutons to throughout our field area are the youngest and most recent tectonic activity observed. They were probably formed after the collision, crustal thickening and the magmatic activity following it.

Conclusions

The ages found by the zircon analysis were helpful in unraveling the tectonic time scale for the geologic events occuring on the North China Craton and southern margin of the Central Asian Orogenic Belt. The four quartzites from the passive margin display minimum zircon ages of 1.2 b.y. and maxima at 1.6 to 2.5 billion. The southern sandstones of the molasse basin have minimum zircon ages of ~270 Ma and older maxima at 400 Ma and 1.9-2.0 to 2.4 billion years. Two plutons had 400 to 500 Ma ages and all others had ages of ~262 Ma. These data suggest that the NCC craton remained a passive margin until ~500 Ma, during which it largely received sediments from the NCC. Subduction, magmatism and volcanic arc formation occurred between 500-400 Ma, southern basin formation between ~270-260 Ma and final collision between the NCC and CAOB and intrusion of post collision granites by ~260 Ma. Further research is being conducted on this area through other methods of geological analysis, such as petrology, geochemistry, and structure. More field research will also be conducted to either confirm or disprove our current tectonic model.

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